Centruroides exilicauda Envenomation in Arizona

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A retrospective survey of 1,135 telephone calls during 1980 and 1981, reporting scorpion envenomation to the Arizona Poison and Drug Information Center, was reviewed. Of these, 438 calls identified Centruroides exilicauda *as the offending scorpion on the basis of description of the arthropod and consistency of physical findings and clinical course. Envenomation by* C exilicauda *occurred primarily in adults during the summer and early fall months of the year. Although most patients (92%) were treated at home with conservative therapy, 8% of patients either came to or were referred to a medical facility. Children younger than 5 years were frequently brought or were referred to either emergency care or inpatient hospital care. We conclude on the basis of this series that despite the historical reputation of lethality associated with envenomation by* C exilicauda, *most envenomations by this scorpion are relatively minor. The other important observation was that children younger than 5 years appear to be particularly prone to severe toxicity.*

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Scorpion envenomation is a major reason for telephone calls to the Arizona Poison and Drug Information Center. *Centruroides exilicauda,* the only truly dangerous species of scorpion in Arizona, is distinguished from other genera by its slender body (Figure 1) and a small tubercle at the base of the stinger.[1] Patients envenomated by this scorpion have a distinct and typical clinical course including local pain, numbness or hypoesthesia, increased salivation, agitation, wheezing, tachycardia, hypertension and muscle spasm. Previous reports of cases have been based on physician contacts, clinical experiences and hospital populations.[2-4] A retrospective review of two years of telephone calls from patients envenomated by this scorpion was undertaken to evaluate the clinical course of these patients and to establish a basis for improved management.

Methods

A total of 1,135 cases of scorpion envenomation reported during the years 1980 and 1981 to the Arizona Poison and Drug Information Center in Tucson were reviewed. The following information was extracted from the poison control form: age, sex, preexisting medical conditions, current medications, time of exposure, description of scorpion, home management (analgesics, cold pack, antihistamine), description and duration of pain and emergency room or physician treatment. Patients were called at 1, 5 to 8, and 24 hours, with additional calls at 24-hour intervals if symptoms persisted. Those patients with signs of local ecchymosis, erythema and swelling were eliminated from the series as not having symptoms consistent with a diagnosis of *C exilicauda* envenomation. Envenomated patients with the typical syndrome of *C exilicauda* sting were included even if a detailed description of the scorpion was not available.

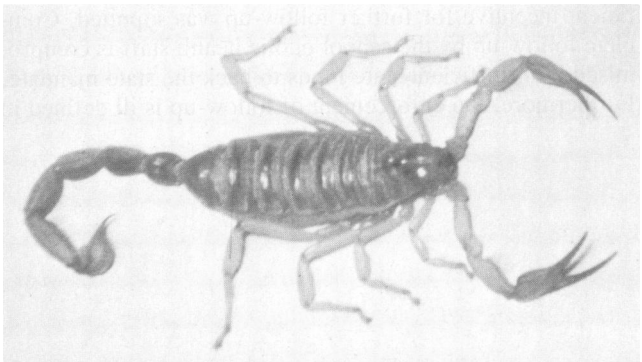

Figure 1.—*Centruroides exilicauda* showing the typical slender pincers and tail segments. (Photograph courtesy of Findlay Russell, MD, PhD.)

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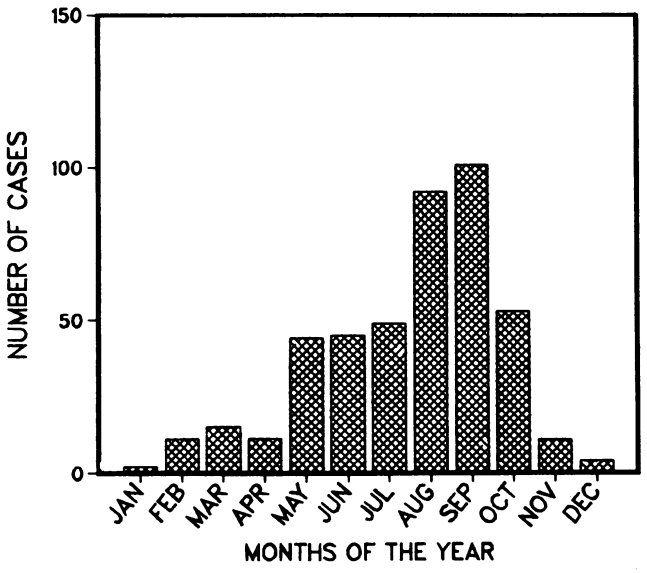

Figure 2.—The incidence of *C exilicauda* envenomation is plotted as a function of reporting month from a series of 438 cases reported to the Arizona Poison and Drug Information Center.

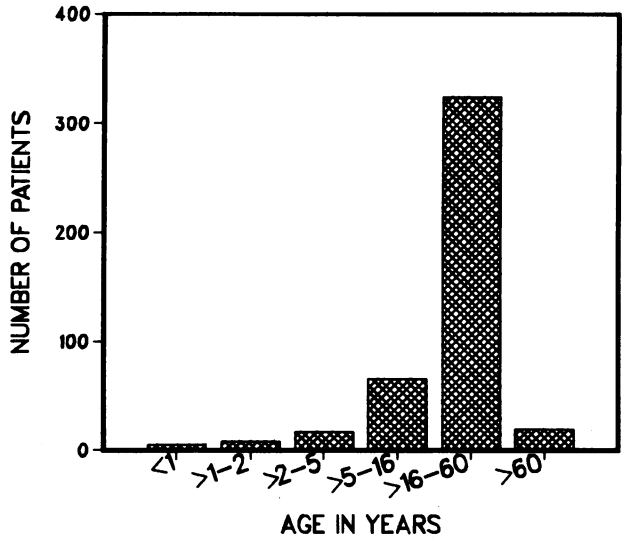

Figure 3.—The age distribution of patient contacts is shown for envenomation by *C exilicauda* in Arizona.

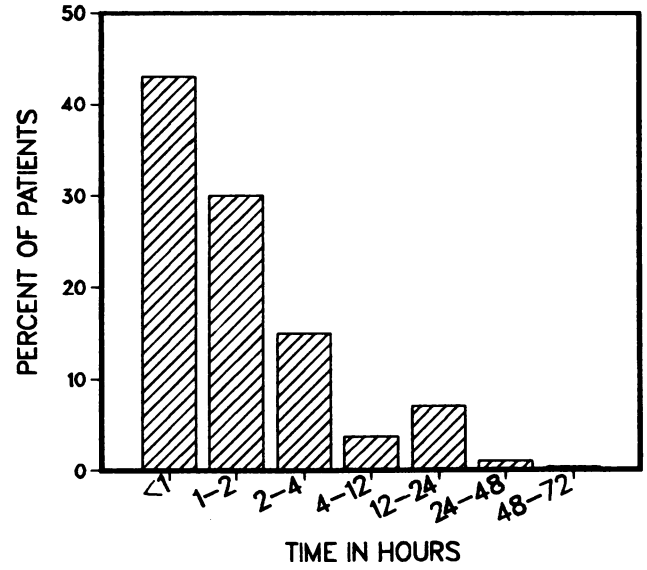

Figure 4.—The number of patients describing local pain due to *C exilicauda* envenomation is shown versus the maximal duration of this symptom in hours.

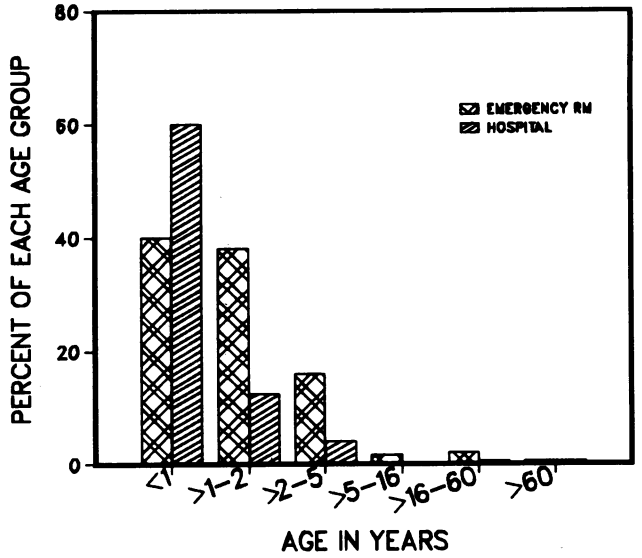

Figure 5.—The percentage of patients from each age group seeking or requiring either emergency room or inpatient hospital care is shown as a distribution of age in years.

Results

The 1,135 calls reviewed were widely distributed throughout the state. Of these, 438 were identified as being caused by *C exilicauda* envenomation. Monthly distribution of stings showed a high prevalence in the summer and early fall months (Figure 2). The age range of patients was from 6 months to 81 years with a distribution favoring the adult age group from 16 to 60 years (Figure 3). There was a slight predominance of male patients, 245 compared to 193 females.

The most common symptom was local pain (70%) with sensory abnormalities in the extremities reported in 234 patients. The majority of patients had a relatively short duration of pain (less than 4 hours) (see Figure 4). In a subjective description one patient described the pain as severe, seven patients described it as moderate and the remaining 300 patients as mild.

Agitation or hyperexcitability was described for 5% of the patients. The group younger than 2 years, however, had an 80% incidence of hyperexcitability. The finding of hyperexcitability was described in all children younger than 1 year. The envenomation was located on the foot in 52% of cases and on the hand in 40%. The remaining 8% had various contact points. Eight of the 438 patients had been stung more than one time.

In all, 92% of the patients were treated conservatively in the home. The remaining 8% either were referred for medical care or came themselves to a medical facility. As can be seen in Figure 5, there was an age-related variability in the number of patients receiving medical care. All patients younger than 1

year were either admitted to hospital or seen in an emergency facility. In the 1- to 2-year and the 2- to 5-year age groups a similarly high rate of either emergency room or inpatient hospital care was evident.

Those patients who stayed at home used mild analgesics and local cold compresses for discomfort. Among the group seen either by private physicians, at emergency facilities or in a hospital, various regimens were prescribed. In patients admitted to hospital, phenobarbital was given for agitation or hyperactivity, and one patient, 2 and a half years of age, also received calcium gluconate, which was reportedly effective in relieving muscle spasms. One man admitted to hospital (age 39 years) was given scorpion antivenin prepared from goats for bradycardia, hypertension and laryngeal spasm. In this single case the symptoms reportedly abated within one hour. Emergency room treatment included observation, cold compresses and nonnarcotic analgesics; however, one patient was given phenobarbital and two patients received diphenhydramine.

Discussion

There are 650 known living representatives of scorpions, divided into six families. In North America all of the dangerous species are in the family Buthidae. *C exilicauda* is one of the neurotoxic species of this family and inhabits Arizona, western New Mexico, California, parts of Texas and northern Mexico.[5] *C exilicauda* shows much interpopulation variability and is now believed to be synonymous with *C sculpturatus*.[6]

The original description of *C sculpturatus* by Ewing was based on two adults and two immature specimens collected in 1927 at Tempe, Arizona.[7] Ewing described the general color of this species as yellowish brown with no dorsal stripes, spots or other markings. Stahnke[8] described a new species with two dark dorsal stripes, which was found in the same general areas as *C sculpturatus* and was named *C gertschi*. Laboratory studies soon showed, however, that venom of this species was almost identical, both from a biochemical viewpoint and in toxicity, with that of *C sculpturatus*. The name *C gertschi* was abandoned. Later, Stahnke found that litters produced by patternless scorpions also contained striped individuals. Further study revealed that *C sculpturatus* was actually represented by four color phases ranging from the characteristic unpatterned straw color to striped specimens.[8]

Williams[6] compared *C exilicauda* from Baja California with *C sculpturatus* from Tempe, Arizona, and found only insignificant differences in morphology, reflecting only local racial adaptations. Upon evaluating the taxonomic characteristics of *C exilicauda*, Williams observed that species are generally darker when taken from habitats with dark substrate and lighter when taken from habitats with light substrate.[6] Also, a difference in body size was noted in *C exilicauda* from different regions.[6]

Scorpions are arthropods that have a hard exoskeleton. The cephalothorax is covered dorsally by a shield called the carapace and has a powerful pair of pincers anteriorly. The preabdomen consists of seven segments and the postabdomen, or tail, consists of six segments.

The sixth segment of the tail is a bulbous enlargement called the telson, and tapers to a stinger. Within the telson are two venom glands with independent ducts leading to an opening near the stinger,[9] and secretion of the venom is of apocrine type. *C exilicauda* can be differentiated from other species by the presence of a small subaculear tooth (tubercle or hair) at the base of the stinger.[3]

The size of *C exilicauda* ranges from about 1.3 cm when the young leave the mother's back to about 7.6 cm when they are fully grown. *C exilicauda* are sometimes called "bark" scorpions because of their favored habitat under the loose bark of trees and in crevices of dead trees and logs. The bark scorpions characteristically rest their tails on the substrate while ground scorpions arch the tail over their back. *C exilicauda* have a negative geotaxis which enables them to cling to ceilings and the underside of objects.[10] Therefore, many people are stung as they pick up objects they have failed to look under, or when they attempt to pick scorpions off of walls and ceilings. The species is nocturnal and the greatest activity is at night. During the day they seek out moist, cool microhabitats under lumber piles, bricks, stones and debris. They may crawl into houses and hide under clothing, in shoes or in other objects.

Scorpions are predacious, feeding for the most part on insects and other arthropods; prey is usually grasped with the pincers and stung by means of the scorpion arching its postabdomen over its own head. The prey is then torn and crushed with the mouth parts; only the liquified tissue is ingested. Solid material is ejected as small pellets.

Scorpion envenomation from *C exilicauda* is a very common occurrence in the southwestern United States from April to November. Although there are more than 20 species of scorpions recorded in Arizona, *C exilicauda* is quite distinguishable from the nonlethal species. The base color of the body is pale to golden yellow (straw colored). The entire body (especially the joints of the legs, pincers and tail) is long and slender. This is in contrast to the stubby or chunky appearance and darker color of many other species.

C exilicauda venom contains vertebrate neurotoxic proteins.[11-13] The venom is thermostable and the composition varies with the season, age and nutritional state of the scorpion.[14]

The minimum lethal dose of *C exilicauda* venom in mice is 1.12 mg per kg of body weight,[15] placing this venom among the most potent animal venoms.[16] Following envenomation, phenomena generally appear in order: immediate local pain, hyperexcitability, increased salivation, increased respiration, muscle twitching and contractions leading to convulsions, spastic paralysis and respiratory failure, which may occur from a few minutes to several hours after the sting.[17]

General neurotoxicity is of an excitatory nature, including the autonomic (parasympathetic and sympathetic) as well as the skeletal neuromuscular systems as observed from human and animal envenomation.[17] The most common parasympathetic symptoms include salivation, lacrimation, sphincter relaxation, gastric hyperdistension, bradycardia and hypotension. The typical sympathetic symptoms include mydriasis, piloerection, perspiration, hyperglycemia, tachycardia and hypertension. The effects on the skeletal muscle are indicated by twitching, spasms and muscle contractions.[17]

Cardiovascular effects include an initial increase in cardiac output, tachycardia and hypertension followed by arrhythmias, bradycardia and hypotension.[18,19] Hypertension is a very characteristic effect of all buthid venoms and has been

observed in humans and a wide variety of laboratory animals.[17] Tachycardia is caused by the release of catecholamines from sympathetic nerve terminals, which is a result of preganglionic, ganglionic or postganglionic stimulation or of sympathetic stimulation of the adrenal gland. Bradycardia has been reported to be due to the release of acetylcholine by action on vagal ganglia and postganglionic nerve endings in the heart.[20]

Laboratory animals injected with *Centruroides* venom demonstrated respiratory irregularities expressed by the intermingled irregularities in rate, with periods of apnea and an increase in depth.[21] Higher doses resulted in respiratory paralysis in the expiratory position. Bronchiolar obstructions caused by secretions and laryngeal and bronchiolar muscle contraction are common manifestations of scorpion envenomation that contribute to respiratory distress.

Epidemiologic studies involving venomous animals are often hampered by an inability to obtain the specific animal for identification. In the case of the scorpion, *C exilicauda*, this problem is lessened by the relatively specific symptoms produced by the species. By not including patients with local swelling, erythema or ecchymoses typical of other local scorpions, a group of patients can be identified for study.

The present series represents a large sampling of patients in and out of hospital. One unexpected finding in this study was the large number of scorpion contacts in this state. In a previous publication on *C exilicauda*,[3] this arthropod was reported as the most lethal venomous animal in Arizona. Since 1960 the incidence of death following scorpion envenomation has steadily declined, despite an increase in the population of the state, leading one author to suggest that the decrease may be related to less reliance on drugs such as meperidine chloride and amobarbital.[3] The last verified death from a scorpion sting in Arizona was in 1968, in a 5-month-old infant (F. E. Russell, MD, PhD, oral communication, January 1983). The present study indicates that the vast majority of scorpion contacts is not serious. Indeed, no lethal cases were reported. The majority of scorpion envenomations occurred in adults, and reactions were minor.

This study clearly identifies the group of those under 2 years of age as being at high risk for requiring hospital admission. These data may be biased by a failure to recognize milder envenomations in this age group unless the scorpion is observed. The report of Rimsza and associates[2] of a series of patients admitted to four hospitals in the Phoenix area over an eight-year period is consistent with the present findings. In their series of 24 patients, 80% were younger than 10 years and 85% had symptoms of severe agitation.

Since one of the purposes of this study was to develop management protocols for telephone contacts involving scorpions, we conclude the following:

- The majority of *C exilicauda* envenomations occur in adults. The symptoms are pain, hypoesthesia or paresthesia of less than four hours' duration. These patients can be safely managed in the home with simple symptomatic measures.
- Children younger than 2 years suffering from a sting by this scorpion are often agitated or hyperexcitable and frequently require admission to hospital.
- Despite the historical suggestion of high lethality associated with Arizona scorpions, no deaths occurred in this series.

It is clear that further study on the management of scorpion envenomation is indicated. There is no consensus on the medical treatment of these envenomations. Controversial questions such as the use of antivenin, phenobarbital and calcium gluconate for scorpion envenomation remain unresolved, and further studies should stress documentation of both the safety and efficacy of these therapeutic approaches.

REFERENCES

1. Stahnke HL, Stahnke J: The treatment of scorpion sting. Ariz Med 1957; 14:576
2. Rimsza ME, Zimmerman DR, Bergeson PS: Scorpion envenomation. Pediatrics 1980 Aug; 66:298-302
3. Stahnke HL: Arizona's lethal scorpion. Ariz Med 1972 Jun; 29:490-493
4. Russell FE, Madon MB: The Introduction of the Scorpion *Centruroides exilicauda* Into California and Its Public Health Importance. Los Angeles, Los Angeles County Health Dept Special Bull, 1979
5. Ennik F: A short review of scorpion biology, management of stings, and control. Calif Vector News 1972; 19:69-80
6. Williams SC: Scorpions of Baja California, Mexico, and adjacent islands. Occasional Papers of Calif Acad Sci 1980 Jul; 135:1-127
7. Ewing HH: The scorpions of the western part of the United States with notes of those occurring in northern Mexico. Proc US Nat Mus 1928; 73:1-24
8. Stahnke HL: Some observations of the genus *Centruroides* (Buthidae, Scorpionida). Entomol News 1971; 82:281-307
9. Keegan HL: Scorpions of Medical Importance. Jackson, University Press of Mississippi, 1980, pp 3-17
10. Stahnke HL: The genus *Centruroides* (Buthidae) and its venom; *In* Bettini S (Ed): Arthropod Venom. Berlin/Heidelberg, Springer-Verlag, 1978; pp 278-307
11. Watt DD, Babin DR, and Mlejnek RV: The protein neurotoxin in scorpion and elapid snake venom. J Agr Good Chem 1974; 22:43-51
12. Babin DR, Watt DD, Goos SM et al: Amino acid sequences of neurotoxin I from *Centruroides sculpturatus* Ewing. Arch Biochem Biophys 1975; 166:125-134
13. Babin DR, Watt DD, Goos SM, et al: Amino acid sequences of neurotoxic protein variants from the venom of *Centruroides sculpturatus* Ewing. Arch Biochem Biophys 1974; 164:694-706
14. Yarom R.: Scorpion venom: A tutorial review of its effect in men and experimental animals. Clin Tox 1970; 3:561-569
15. Stahnke HL: Variables in venom research. Biosystems 1963; 34:64-71
16. Zlotkin E, Rochat H, Kupeyan C, et al: Proteins in scorpion venoms specifically toxic to arthropods, *In* Kaiser E (Ed): Animal and Plant Toxins. Berlin, Godman-Verlag, 1973, p 29
17. Zlotkin E, Miranda F, Rochat H: C. Chemistry and pharmacology of Buthidae scorpion venom. *In* Bettini S (Ed): Arthropod Venom, n.s. vol 48, Berlin/Heidelberg, Springer-Verlag, 1978, pp 317-369
18. Patterson RA: Physiological action of scorpion venom. Am J Trop Med Hyg 1960; 9:410-414
19. Braun K, Stern S, Werkson S: Sympathetic effects of scorpion venom on the cardiovascular system. Israel J Med Sci 1969; 5:853-854
20. Freire-Maia L, Pinto GI, Franco I: Mechanism of the cardiovascular effects produced by purified scorpion toxin in the rat. J Pharmacol Exp Ther 1974; 188:207-213
21. Freire-Maia L, Azevedo AD, Costa Val VP: Respiratory arrhythmias produced by purified scorpion toxin. Toxicon 1973; 11:255-257